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ABSTRACT

An analysis of energy costs and conservation in educational facilities in the United States is presented in this report. Tables and text give dollar figures for energy expenditures in education since the first oil embargo. Energy conservation through facilities management and through facilities modification is stressed. Recommendations are presented for both local and national levels. A bibliography is included. (MR)

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Energy and Educational Facilities: Costs and Conservation

SE 026 791

A report from Educational Facilities Laboratories to the United States Energy Research and Development Administration

April, 1977

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I. EDUCATION AND ENERGY - A NATIONAL VIEW

Education is the primary activity of approximately 64 million Americans. This total includes almost 49 million school children, over 11 million students enrolled in colleges and universities, three million teachers and faculty, and about 300,000 school superintendents, principals and supervisors. The expenditure for private and public education - kindergarten through graduate school - is estimated at $120 billion for 1975-76. Thus one out of four Americans is directly involved in the educational enterprise which accounts for 8% of the gross national product.(1)

The physical plant - elementary and secondary schools, colleges, dormitories, libraries, research laboratories - that houses the educational enterprise is large. The area of all the educational facilities in the U.S. is estimated at over seven billion square feet.(2) This is equal to 260 square miles - almost four times the size of the District of Columbia.

The energy bill for heating, cooling, and lighting this plant, as well as cooking meals, and operating the equipment, was 3.19 billion for the 1975-76 academic year for all educational facilities.

In 1975-76 the elementary and secondary schools expended almost $1.9 billion on energy, and higher education spent $1.3 billion. Of this total, publicly supported education spent almost $2.7 billion and the non-public sector spent $479 million. The largest component of non-public education, the Catholic K-12 schools, spent over $129 million on energy (see Table A1 Appendix).

The estimated cost of energy for the 1976-77 academic year will be $3.4 billion. Higher education will spend $1.4

billion, and primary and secondary education will spend almost $2.0 billion on fuel and utilities.(3)

Educational facilities consumed an estimated 11.5 billion therms last year, which was 5% of the nation's heating and cooling consumption and 1.5% of the nation's total energy consumption of 730 billion therms (73 quadrillion Btu's).(4)

Elementary and Secondary Schools

The nation's public elementary and secondary schools account for the largest segment of the nation's education energy bill. The 16,000 school districts spent over $1.7 billion on their 44,838,000 students in 1975-76. This was an average of $37.94 per pupil and represents a 25% increase over the $30.12 per pupil of 1974-75. The estimated average cost for 1976-77 will be $41.68 per pupil.

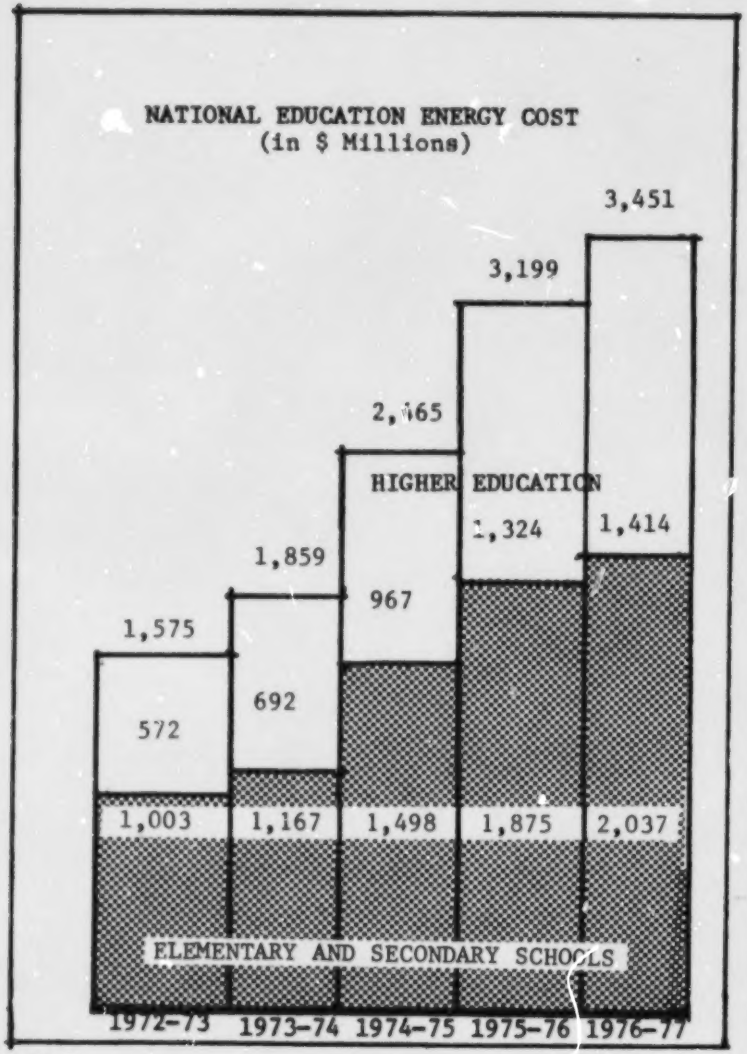
The Federal Energy Administration (FEA) has estimated that the median (not average) per pupil consumption of energy for 1974-75 was 15,768,000 Btu's, at a cost of $29.77 per pupil. Table 1 gives a quick overview of the FEA data on elementary and secondary energy consumption and cost.(5) (A breakdown by region and size of district is shown in Table A2 Appendix.)

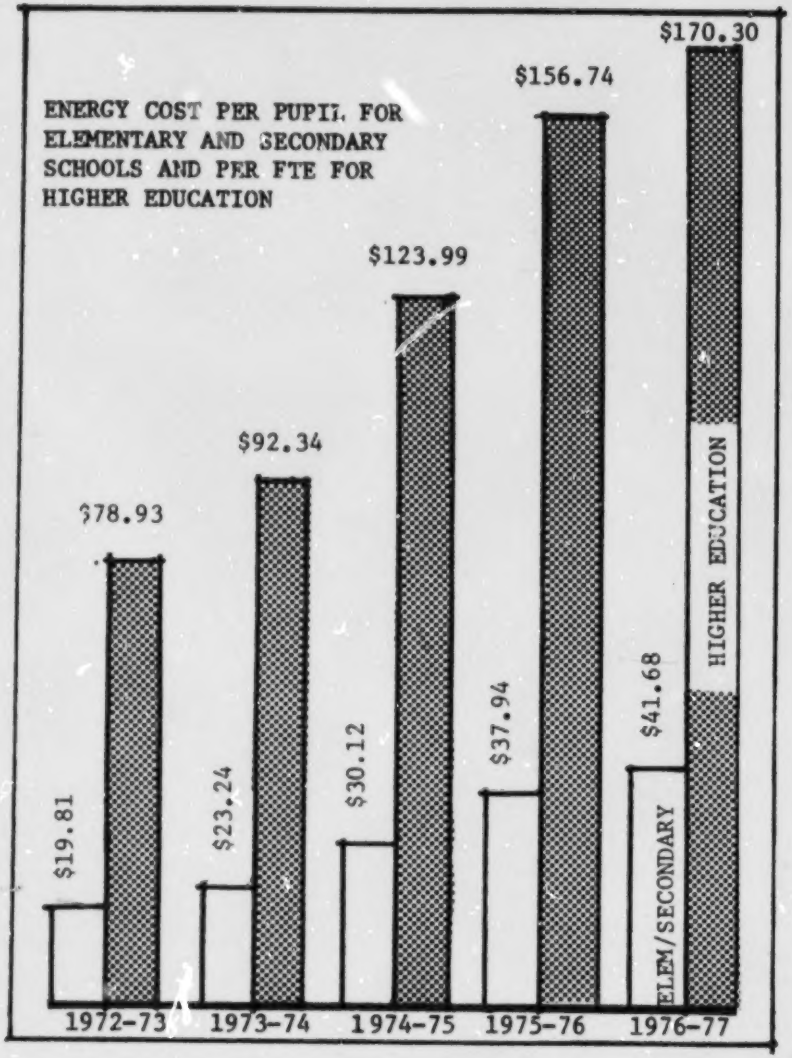
Table 1
Energy Consumption K-12 & Cost for 1972-73 & 1974-75

Year	Therms Billions	Total cost ($000's)	Median Btu's sq ft (000's)	Median Btu's pupil (000's)	$/sq ft	$/pupil
1972-73	7.45	$938,000	161	16,300	$.20	$20.07
1974-75	7.12	1,452,000	148	15,800	.29	29.77
% change	-4.6	+54	-8.1*	-3*	+45	+48.3

*The difference in percentage drop is the result of a 2.6% increase in square footage and a 2.6% decrease in population.

The per pupil energy cost presented in Table 2 "Average Utility and Energy Cost Per Pupil," has been developed from FEA data and from a survey by Market Data Retrieval Inc. for Amer-


NATIONAL EDUCATION ENERGY COST
(in $ Millions)
3,451
3,199
2,465
HIGHER EDUCATION
1,859
1,575
967
692
572
1,003
1,167
1,498
1,875
2,037
ELEMENTARY AND SECONDARY SCHOOLS
1972-73
1973-74
1974-75
1975-76
1976-77


ENERGY COST PER PUPIL FOR
ELEMENTARY AND SECONDARY
SCHOOLS AND PER FTE FOR
HIGHER EDUCATION
$170.30
$156.74
$123.99
$92.34
$78.93
$19.81
$23.24
$30.12
$37.94
$41.68
ELEM/SECONDARY
HIGHER EDUCATION
1972-73
1973-74
1974-75
1975-76
1976-77

ican School & University magazine. The energy cost per pupil is an extrapolation and is as close as present information and survey techniques can provide. (The actual cost per pupil may actually be somewhere between the energy cost figure given and the total utility cost per pupil.)[6]

Table 2

Average Utility and Energy Costs Per Pupil

	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
Heat	$7.11	$7.94	$9.32	$13.85	$17.53	$19.32
Other utilities	14.49	16.23	19.03	22.85	28.74	31.52*
Total utility	21.60	24.17	28.35	36.74	46.27	50.84
Energy cost	17.71	19.81	23.24	30.12	37.94	41.68

*Figure includes telephone ($5.39), water, and sewage.

A study of energy consumption in commercial industries (schools are included in the definition of the commercial sector), for the FEA estimated total energy consumption for elementary and secondary to have been 881,702 billion Btu's (8.8 billion therms) in 1974-75. Of this amount, 48% was provided by natural gas, 24% oil, 19% electricity, 7% coal and 2% miscellaneous (see Appendix A3).[7] The distribution of these energy components in school facilities, however, does not agree with the FEA survey of school energy consumption and cost (see Appendix A4).

Higher Education

For higher education, figures generated by the American Council of Education through its 1976 Higher Education Panel (HEP) Survey #31, Impact of Energy Cost Increases and Energy Conservation Program of Colleges and Universities, conducted during the fall of 1976, gave the following picture.

Table 3

Energy Consumption in Higher Education

Year	Therms Billion	Total cost ($000's)	Btu's sq ft (000's)	Btu's FTE* (000's)	$/sq ft	$/Student
1972-73	4.25	$554,806	211	60,400	$.276	$ 78.93
1974-75	4.01	934,869	184	52,700	.434	123.99
% change	-5.6	+70.1	-14.6	-15.3	+57.2	+57.1

*FTE - The number of full- and part-time students expressed in terms of full-time students.

Although higher education has decreased consumption by about 15% per square foot and per FTE, the increased area and higher fuel costs have increased expenditures by 70% over all.

An extrapolation of this data, using the same escalation rate as the elementary and secondary sector, reveals that the cost of energy was $156.24 per FTE for 1975-76, and will be $170.30 for 1976-77.

Table 4 gives an overview of the percentage of institutional operating budget expended for energy. In 1972-73, before the "energy crisis," 62% of the nation's colleges and universities spent 3% or less of their current fund expenditures for fuel, and 94% used 5% or less. In 1974-75 only a third of the institutions spent 3% or less and three quarters used 5% or less (see Table A5 Appendix, for detailed breakdown).

Table 4

Impact of Energy Cost on Institutional Operating Budgets & Cost per Therm

Percentage of Operating Budget	Percentage of Institutions	
	1972-73	1974-75
3% or less	62	32
3.1-4%	86	59
4.1-5%	94	78
over 5%	6	22
Median	2.7	3.6
$/Therm	$.131	$.235

The cost increase per therm was 79.4% nationally (see Table A6, Appendix, for breakdown by region, fuel, type, and type of institution).

For higher education the cost of energy has been one of the three most inflationary items in the institutional budget. Using a 1967 price index of 100, the cost of energy was 129 in 1972-73, and rose to 219 in 1975-76 (see Appendix A7).[8]

The Buck Stops Here The doubling of energy costs has hit education particularly hard. Unlike other segments of the economy, including government, education cannot easily pass along the increased cost of energy to the consumer. The increased cost of energy can only be covered by increased tuition, higher local taxes, and increased state and federal support - which in today's tight economy would be difficult to accomplish.

II. ENERGY CONSERVATION IN EDUCATIONAL FACILITIES - AN OVERVIEW

It is clear that the increased cost of energy has had an adverse impact on education. The labor intensive nature of the educational process leaves little stretch room for non-personnel expenses. As budgets are basically inelastic, increased costs in energy tend to be made up by decreased expenditures in other components of the institutional budget. Therefore services and programs must be reduced in order to pay for energy.

On the national level, education must compete with industry, transportation, commercial enterprises, and residences for the available energy supplies. Reductions in consumption by education should be an important component in achieving over all national conservation goals.

The FEA has estimated that by 1985 the equivalent of three million barrels of oil per day can be saved through an active energy conservation program. An energy reduction of 30% from the 1974-75 academic year by education, which is possible with improved environmental management and modest capital investments, can save 6% of the FEA energy conservation target.[9] Not only can the education plant be made more efficient, but active conservation measures visible to students and the community can serve as a model of good energy management.

There are two principal methods for energy conservation in educational facilities within the context of current codes and regulations:

1) Improved environmental management of existing facilities

2) Improved environmental support systems through modi-

fications of facilities

Examples of environmental management are:

- improved maintenance and operation of mechanical systems
- reduced room temperature
- consolidation of user activities during evenings and weekends so only a few spaces of a building have to be lighted and heated
- reduced lighting levels that meet the requirements of the task

Examples of facility modifications are:

- conversion of incandescent lights to fluorescent, mercury vapor, and other more efficient light sources
- improved insulation
- installation of automated fresh air valves
- installation of system for monitoring and control of building environment
- reducing exterior glazing

There is also a third approach: modifying environmental standards for existing educational facilities and new construction. Such modifications include light level reductions, fresh air limitations, reduced air exchanges, and reduced room operating temperature which takes advantage of sensible heat gain from space occupants.

The new ASHRAE Code 90 is a major step in this direction. The Executive Summary report on the impact of this new code stated that "under a strict interpretation of the standard.... the unweighted average reduction in annual energy consumption relative to 1973 construction and operational practices across the four locations investigated, was 48.1% for school buildings." ASHRAE 90 would decrease the cost of construction by $.44 per square foot. The estimated annual energy savings for schools would be $.70 per square foot. While ASHRAE 90 requires additional design services, estimated at a per square foot cost of $.15, the savings affected by it would have a 4.6 months straight payback period.

III. ENERGY CONSERVATION THROUGH FACILITIES MANAGEMENT

A program of energy reduction through facilities management is a logical first step in a long-range conservation program. It includes more efficient utilization of facilities, improved operation and maintenance of mechanical systems, reduction of lighting, heating and cooling levels, and the concept of "Quick Fix." Quick Fix is defined as an energy consumption reductive measure that achieves rapid and significant savings at a negligible cost, or at a cost with a return on investment of six months or less.

Elementary and Secondary

Elementary and secondary schools have generally been built with the major emphasis on keeping the first cost (construction cost) as low as possible. The result has been economically built schools that are expensive to maintain and operate. The typical school is poorly insulated, has large expanses of loosely fitted windows, mechanical systems that are difficult to regulate, and plant personnel who are often insufficiently trained.

The national savings through improved operation of the physical plants with little or no capital expenditures is estimated by EFL to be $665,890,000 (see Table 5). The projected savings amount to $14.85 per child (based on a student population of 44,838,000).

Table 5

Estimated Savings in Electricity, Fuel, and Dollars Achieved by Operating all U.S. Public Elementary and Secondary Schools at PSECS Guideline*

Savings in Millions

		Electricity		Fuel		
Level	No. of Schools	kwh	$	Therms	$	Total Savings
Elementary	60,624	3,493	$104.8	821.3	$164.3	$269.1
Secondary	24,730	7,116	213.5	916.7	183.3	396.8
Totals	85,354	10,610	$318.3	1,738.0	$347.6	$665.9

Note: The following costs were used: Electricity $0.03/kwh, Fuel $0.20/Therm.

*The Public School Energy Conservation Service (PSECS), established by EFL in conjunction with the FEA, is a computer-based technical service designed to assist school districts in the development of effective energy conservation programs for their physical plants. Using computerized models, the service operates on two levels. The first, a self audit program, provides suggestions for bringing the plant down to guideline levels with little or no expenditures. The second level, uses life cycle costing to determine the most cost effective facility modifications requiring capital investment for each school.

Projections made by EFL's PSECS indicate that some energy savings are possible in 85% of the 766 elementary schools in a weighted sample. The individual savings vary with the age and construction of each school. A typical elementary school could save approximately 1.48 kwh/sq ft per year and 0.315 therms/sq ft per year. For the average elementary school containing 41,000 sq ft, the projected savings in energy and dollars are based on $.03/kwh for electricity and $0.20/therm for fuel.

Electricity	60,335 kwh	=	$1,810
Fuel	12,067 therms	=	2,573
Total savings per school			$4,383

In the PSECS/EFL survey of 129 elementary school districts conducted in January 1977, 72 districts reduced energy consump-

tion and 57 stayed the same or increased consumption. For the 72 that showed savings, the average drop in electricity was 9.2% and 11% for fuel consumption. These measures were taken to achieve the savings:

- reduction of temperature in winter
- increase cooling temperature in summer
- reduction in lighting levels and usage
- reduction in outside air intake
- night, early, and automatic setbacks
- reduced night and weekend use
- reduction of domestic hot water temperature
- increased attention to equipment maintenance
- training and education program for all building personnel
- adjustment and correction of building controls
- reduced night and weekend use

Discussions with those responsible for school operation and maintenance suggest several problems which prevent school districts from improving the efficiency of their plants. Included in the list of constraints are the following: lack of funds for preventive maintenance, not enough trained personnel to operate complex systems, lack of support by superiors for energy management programs, and inferior equipment purchased on low first cost basis.

Until the cold weather in 1976-77, energy conservation was not a priority of most school districts. Of the 124 school districts in the PSECS program during 1975-76, only 52 had programs prior to their participation. Of the 72 who did not have a program prior to PSECS, 28 still do not have an energy management program. School districts, like other components of society, appeared to have "adjusted" to higher prices and are not aware of the level and impact of future increases.

Higher Education

The energy crisis has hit colleges and universities harder than elementary and secondary schools because they are more energy-intensive. Higher education spends three times more for each student than schools do. Higher education enrolls 16% of the

nation's students, yet it accounts for almost one-third of the educational energy consumption and expenditure. Higher education's approach to energy conservation has been as varied and unique as the institutions themselves.

Many colleges and universities have instituted facilities management improvements, including Quick Fix programs at savings of between 10% and 20%. As stated previously, higher education in 1974-75 used 15% less therms per FTE and per sq ft than in 1972-73. It is indicative of the amount of energy that can be saved by simple but effective management measures.

The HEP survey of the nation's colleges and universities showed that 65% of the 533 schools sampled have instituted one or more of the following measures (see Table A8 Appendix).

- reduction in illumination levels and lamp wattage
- temperature range 65-68 degrees in winter
- temperature range 75-80 degrees in summer
- inspections and corrections of valve functions and air filtration systems
- fixing minor water leaks
- substantial night and weekend building shutdown
- manual monitoring of buildings
- reduction of hot water temperature
- manual reduction of fresh air make-up
- campus-wide energy awareness program

The survey indicates that most of the management measures can be easily accomplished by the physical plant department staff responsible for energy distribution and maintenance on campus. The measures listed require the least investment of labor, money, and administrative time. Measures have generally aimed at the largest wasters or excessive users of energy: heating, cooling, and lighting.

Between 1972-73 and 1974-75, higher education increased its square footage by more than 164 million sq ft, an 8% increase. At the same time, energy consumption was reduced by almost 6%. On a per pupil or per sq ft basis, energy consumption was reduced by 15%. The over all savings in energy was 23,600,000,000,000 Btu's (236 million therms), which saved

$55 million.

Despite these significant savings, the potential for energy savings through environmental management/Quick Fix has certainly not been exhausted. More can be done in this area of conservation. The amount of energy saved through Quick Fix, depends on the amount of effort exerted by the institution. For example, Michigan State University (MSU) has found that for many buildings a control tune up with minor control modifications will produce a first year return of about $10 in energy savings for each $1 invested. Through facilities management primarily MSU has reduced their energy use index from 229,850 Btu's/sq ft to 183,175 Btu's/sq ft. There is a point of diminishing returns, but it would be safe to state that that point has not yet been reached by all institutions.

IV. ENERGY CONSERVATION THROUGH FACILITIES MODIFICATIONS

A second, and logical step, in an energy conservation program, after implementing improved facilities management, is the introduction of facilities modifications. These capital investments are made on the basis that the savings in energy will, over a few years, cover the costs of the capital investment. This payback period will vary with the amount of energy saved and the costs of the modifications - and as energy costs escalate payback periods shorten.

Elementary and Secondary

Elementary and secondary schools have done very little in facility modifications. This statement is made after extensive searching by EFL staff and through questioning 20 major consulting engineers that do institutional work. Of the dozen schools that are contemplating modifications, the following list of potential measures has been developed:

- increasing insulation
- weather stripping doors
- installing storm windows
- replacement of boilers
- adding new temperature controls
- reducing glass area
- conversion of burners
- installation of air handling equipment
- reuse of return air
- replacement of incandescent lamps with HID lamps
- elimination of automatic dishwasher with electric boosters

School administrators have stated that they simply do not have the resources to undertake a comprehensive energy plan, including the professional services required, for facilities modifications. This is true even though the long-term cost avoidance would benefit the district. Further, capital modi-

fications require a different budgeting process (often including voter approval) and money must then be raised in the bond market.

Even EFL's PSECS Capital Improvement Program, which was offered free before January 1, 1977, achieved limited response. Again, it seems that energy conservation is still not a high enough priority for most school districts to invest capital resources. This will change as the price of energy continues to escalate, and school districts recognize the soundness of such investments.

Several major school bond issues - notably Dallas and Fort Worth - have recently been passed and include facilities modifications to save energy. In addition, other sources of funding, such as the Public Works Act, are beginning to provide funds to schools outside the normal bonding process. A major project to demonstrate facilities modifications has been conducted by the American Association of School Administrators with funding from FEA. The "Ten Schools Project" demonstrated the impact of capital modifications as prepared by engineering analysis (Table 7). The ten projects have not received capital funding, but when they do, and monitoring is undertaken, they will provide important empirical data. Work in energy conservation for schools reveals there is great potential for energy savings with modest capital investments.

As an illustration of this potential, projections on three commonly suggested modifications have been prepared and summarized in Table 6. The projected number of schools to which these modifications could be applied has been derived by applying various criteria to the data bank on schools and school types developed in the PSECS project. (Example: only schools with hot water boilers can use the modification in line #2. The computer estimates this number to be 32,500 schools.)

Table 6

Projected Savings from Selected Capital Modifications by PSECS

National savings in millions

per school savings in actual dollars

Modification	Electricity kwh	Electricity $	Electricity $/school	Fuel Therms	Fuel $	Fuel $/school	National capital cost in millions	Cost per school	Payoff years	No. of schools
1. Reduce infiltration	11.9	$0.357	$ 5.00	1,190.3	$243.3	$3,356	$776.3	$10,708	3.26	72,500
2. Sequenced pumps for heating and cooling	1,709	51.3	1,578.00	-------	------	------	113.5	3,492	2.21	32,500
3. Add setback clock	7.0	0.210	7.50	69.9	14.0	500	28.2	1,007	1.98	28,000

Note: The following factors are used: electricity $0.03/kwh; fuel $0.20/therm; 5,600 heating degree days.

(See Appendix All for complete list)

Table 7

Summary: AASA "Ten Schools Project"

Location	Year built and sq ft	Fuel	Modification	Est. cost	Recovery time
Warwick, R.I.	1965, 67 27,610	gas	1.reduce outside air 2.night setback 3.replace boiler 4.add roof insulation	$37,800	5 years
Glen Rock, N.J.	1925,39,50 45,384	oil	1.reduce outside air 2.replace boiler 3.chg.temperature settings 4.dampers 5.roof insulation 6.reduce infiltration	39,550	5 years
Langhorne, Pa.	1954,58,67 49,314	oil	1.reduce outside air 2.replace boiler	21,200	9 years
Hindman, Ky.	1957, 66 32,338	gas	1.increase boiler efficiency 2.reduce glass 60%	13,700	6.3 years
Columbus, Ohio	1949, 55 42,765	gas	1.shut down unit vents, summer 2.improve boiler efficiency 3.night setback 4.reduce outside air	25,700	3 years
Lubbock, Tex.	1949,50,56 36,802	gas	1.update and improve controls	1,000	1.5 years
Lincoln, Neb.	1954, 55 32,029	gas/oil	1.reset and rebalance air handling units 2.night setback	10,000	5 years
Sioux Falls,N.D.	1952,56 33,000	gas/oil	1.reduce outside air 2.night setback 3.improve boiler efficiency	20,000	10 years
Stevens Point, Wisc.	1973 44,000	gas	1.improve airconditioning usage schedule 2.improve indoor lighting schedule 3.air temperature reset 4.reduce outside air	3,900	1 year
Kennewick,Wash.	1957 40,124	gas	1.mechanical adjustments 2.night setback 3.roof insulation 4.reduce glass 5.replace incandescent lighting	80,400	7 years

Higher Education

The higher education field tends to group building modifications for energy conservation into two categories: Refit (also called retrofit) and Systems Convert.

Refit measures are those which can achieve a 10% to 15% reduction in energy consumption beyond facilities management/ Quick Fix and which have a 6-month to 3-year payback period. Nationally, this represents a cost avoidance of $100 million to $150 million at present energy costs.

Systems Convert is the most sophisticated and expensive of energy reductive measures. They can achieve at least an additional 10% reduction, and have a payback period of two to five years. Institutions with specialized research facilities, with sophisticated environmental control requirements - such as biological and chemical research laboratories, and medical research facilities - will benefit most from this category of reductive measures. More recent buildings that have sealed environments would also benefit from this type of energy conservation measure. Nationally, Systems Convert could produce an additional cost avoidance of $100 million at today's energy costs.

Refit The following are examples of refit measures that have been instituted in at least half of the colleges and universities responding to the HEP survey:

- conversion from incandescent to fluorescent, mercury vapor quartz, sodium, and other more efficient light fixtures
- time clocks on lighting systems
- analysis of electrical rate structures, power factors, load profiles, and demand peaks
- weather stripping, storm windows, caulking, sun screens, and blinds
- installation of variable speed drives
- review of existing mechanical systems and controls to identify capital investment options
- automated reduction of fresh air make-up
- improve steam line insulation
- installation of water saving shower heads or flow restrictors
- installation of motorized steam valves
- revision of light switch circulatory system to reduce over-lighting

(See Table A9, Appendix for complete listing and percentages.)

Table A9 shows that 57% of the 530 institutions surveyed have reviewed their mechanical systems. An analysis of electrical consumption has been accomplished by 67% of the colleges and universities surveyed, but 33% have not taken this very basic step in developing refit programs. Analysis of campus energy consumption patterns, rezoning, and central monitoring have only been implemented at about a third of the surveyed colleges and universities.

Data from other areas suggest that analysis of energy consumption and utilization has been achieved primarily at large universities and well-known colleges which have extensive plants, complex research facilities, and the financial and personnel resources to undertake a major energy research and reductive effort.

Systems Convert As previously stated, Systems Convert is the most sophisticated and expensive facility modifications that can be undertaken.

Examples of Systems Convert are:

- automation of power plants (controls)
- independent zoned environment controls for laboratories and other specialized space
- conversion to alternative fuel
- rewiring of major electrical systems to minimize demand charges and to avoid established new peaks
- installation of central computerized controls
- installation of computerized building monitoring systems

(See Table A10, Appendix for complete listing.)

One or more of the examples listed above have been implemented at only one-third of the colleges and universities surveyed. Less than 25% of the institutions surveyed have any buildings with computer monitoring and controls. (See Appendix A12 for illustrations of type of modifications undertaken by colleges and universities.)

Summary Refit and Systems Convert require the college or university to direct resources for analysis of campus energy utilization patterns and planning the implementation of conservation measures. The commitment of personnel and capital resources has been made at only a portion of the nation's colleges and universities. The more sophisticated the conservation measure, the smaller the portion becomes.

V. SUMMARY

Educational facilities in America consume 1.5% of all the energy used in the nation, and 5% of the energy used for heating and cooling buildings. Because education involves one out of four Americans, its energy conservation efforts can have a broader impact than suggested by the consumption figures. It can help set the tone for a national conservation program. If the educational enterprise could reduce consumption 30% (3.5 billion therms) below the 1974-75 academic year level, it would achieve 5% of the nation's 1985 conservation goal established by the FEA.

Energy conservation programs involving facilities management (without capital investment) have the potential of a 20% savings of current consumption or a cost avoidance of $600 million. Colleges and universities have made some progress in this area, but not many school districts have.

The same benefits (20% energy savings and a cost avoidance of $600 million) can be achieved by capital investments with payoff periods of up to five years. Some colleges have made such investments, but there is little evidence that school districts are making capital investments. More substantial capital investments with a payback period of up to 10 years can add another 10%-20% reduction. The educational sector has not attempted these.

Many constraints have thus far prevented more extensive conservation programs in educational facilities - lack of funds for basic survey, engineering, and capital improvements, plant operating personnel without sufficient training, and most of all, a sense that energy conservation is not the highest priority when measured against the other crises facing education today.

Finally, preparation of this report has revealed inadequate basic data, or conflicting data, concerning education's share of energy consumption. It has also revealed that information on conservation is fragmented and often unavailable. Because responsibility for education in America is decentralized among 3,000 colleges and universities and 17,000 school districts, it is not surprising that the monitoring of energy consumption and the impact of conservation measures are haphazard and would greatly benefit from a clearinghouse activity.

VI. RECOMMENDATIONS: CONSERVATION PROGRAMS AT THE LOCAL LEVEL AND RESEARCH AND SERVICE PROGRAMS AT THE NATIONAL LEVEL

The recommendations are of two types: the first deals with the conduct of conservation programs at the local level, the second with research and service programs at the national level. All recommendations have been developed through our experience in preparing this report and from EFL's five years of experience with energy programs.

Guidelines for conservation programs at the local level

1. Establish an energy consumption data base: a school district or a higher education institution needs to know where and how much energy is used in its facilities. It needs costs per student, per square foot, and, if possible, by program. A data base should include the following components:
   a) Costs - operating costs, maintenance costs, energy costs, and projected costs.
   b) Facilities - square footage, fenestration and orientation, physical condition, heating, ventilation and airconditioning, and power requirements.
   c) Climate - heating degree days, cooling degree days, winds, and special local conditions.
   d) Institution activities - persons served, programs, times of operation, and special conditions.
   e) Resources - source of funds, interest rates, manpower, fuel availability and alternatives, operations and management.
2. Comparative analysis: the data and analysis developed above should be compared against national and regional averages for facilities of similar construction, program, and climatic zone, or, ideally, compared to models of similar facilities operating

at efficient energy levels.

3. Establish energy conservation goals: two sets of goals must be established. One set that can be achieved with improved facilities management, another set by facilities modification through capital investment.
4. Identify options to meet energy conservation goals: professional engineering and architectural services will be required to define the options and determine their costs, energy savings, and payback periods.
5. Establish a comprehensive, phased energy conservation program: the program will include two components - improved facilities management, and facilities modifications. Management should be implemented before initiating modifications to facilities. Most districts and institutions will require professional help in evaluating their options and developing the comprehensive program.
6. Implementation of energy conservation program: administrators and plant personnel will require training in energy management before attempting to implement a program. Their training will include help with data collection and analysis, economic benefit analysis, and mechanical systems maintenance and operation.
7. Monitoring the conservation program: the energy program should be continuously monitored, evaluated, and adjusted to benefit from the program's own results and from new information from other sources. This monitoring process also provides financial data that can be substituted for the estimated costs used earlier in the program.
8. Information program: all constituents - staff, students, board, citizens or alumni - should be kept apprised of the results of the energy program in order to build support for continuing the program, especially if capital funds will be required.
9. Related educational programs: an energy conservation program provides many opportunities for developing parallel classroom and community education programs on energy and the environment.

Recommendations for national research and service programs

To reach the energy conservation objectives in educational facilities reviewed in this report, EFL recommends the following national research and service programs.

1. Data gathering, monitoring, and information dissemination.

Information is needed at the national and state levels on what's being spent for energy, the size of increases, and the regions carrying the greatest burden of increased energy costs.

At local levels, each district and institution should know not only how much energy is being used (by pupil, by square foot and by program), but also how these costs compare with similar energy-efficient plants. Information from the local levels should be collected at the national level and made readily accessible to school districts and colleges. If EFL's PSECS is supported and expanded to include higher education, it could provide the basis of this service through working in cooperation with the Higher Education Energy Task Force.

State and local educational administrators need to know what capital investments can be made to save further energy, and what their cost-benefits would be. This information should be accessible nationally and constantly updated.

It follows that up-to-date information on the impact of all conservation programs needs to be collected, analyzed, and disseminated nationally as a spur to others.

Also information on the future status of energy is needed to assist with life-cycle costing and similar decisions. This "futures analysis" should include fuel availability, costs, and feasibility of alternative sources.

Citizens - parents, taxpayers, and alumni - need objective information and guidance to help them stimulate constructive energy programs in their school districts and colleges and to influence legislation supportive of these objectives. At present there is no national information source for lay audiences.

2. Research and demonstration projects.

After all the possible energy savings are wrung from improved operations and use of existing buildings, capital investments must be made. Unfortunately, true costs - initial and operating - of capital investments are hard to come by. The history of modifying buildings to save energy is too short. A number of well planned, carefully monitored demonstration projects are needed to build the experience and establish a costing base from which to extrapolate proposed capital improvements. The AASA "Ten Schools Project" is the type of program that needs to be carried forward.

Existing performance standards for buildings need to be re-examined and criteria modified when necessary. There are two types of standards: environmental standards for thermal comfort, fresh air, lighting etc., and architectural and engineering standards for insulation, mechanical systems, and glazing etc. These performance levels are sometimes contained in building codes, state regulations or guidelines, or often are "traditional or standard practices" deeply ingrained in professional practice. Research of another type is needed - research and demonstration projects dealing with reprograming and rescheduling the use of facilities. Much educational space is badly underutilized although we continue to heat, cool, and light it. No program has yet dealt with reducing energy by increasing efficiency of use.

The private sector that supplies the educational facilities market with building materials, mechanical equipment, and construction components, must be encouraged to improve products in response to energy savings criteria developed jointly by owner, design professional, environmental researcher, and the manufacturers' own R & D and marketing specialists.

Automated control systems hold great promise, but objective evaluative criteria are needed. Likewise, methods for improving the function and efficiency of unit ventilators is desirable.

While massive amounts of data are collected by government agencies on climate, energy, and human comfort, only a limited amount of effective data is available to people concerned with energy management and the design of educational facilities. Examples of this are: detailed weather prediction by NOAA (National Oceanic and Atmospheric Administration), and research on heating, cooling, and ventilation made by agencies such as NASA and the navy. A study should be made to determine what information is most useful and how it should be gathered, analyzed, and disseminated.

The ability of public institutions to use alternative self-renewing energy sources must be further explored.

Energy conservation programs should be linked to educational objectives to take full advantage of educational opportunities.

3. Servicing educational institutions.

Competent professional engineering and architectural services must be available to analyze existing plants, sort out options, and initiate operational and capital improvements. Professionals will need to update themselves to become skilled in "energy considerate design". A related need, which is a responsibility of professional associations, is to develop guidelines for standard forms of contracts for energy conservation services.

School administrators and building personnel need in-service training as energy managers so they can analyze current energy use, conduct energy audits and initiate operational changes, monitor the effectiveness of changes, and maintain and operate existing mechanical systems. Short courses - for management personnel and building operators - need to be developed through two-year colleges, regional educational agencies, and state education and energy agencies. School plant operating personnel need advanced training in order to operate the buildings (especially the control systems) to their most energy efficient level. The costs of better trained personnel will add

to personnel budgets. But, it may be possible for well-trained "circuit riders" to oversee the more sophisticated systems on a multi-district, multi-college, or regional basis.

For education to save more money than possible through efficient operations, it must invest capital funds in improved building envelopes, mechanical systems, and controls. Bond issues requiring voter approval are not possible in most districts so grants, loans, or other federal and state subventions will be needed.

An energy extension service should be made part of the cooperative extension service of the land grant colleges and universities. These would serve as energy consultants with staff and computer support that schools, colleges, and private concerns could turn to for energy information. With a PSECS or CERL building energy analysis program, consultants could determine energy conservation programs. This would be an extension of and a new mission for the land grant colleges which were set up to provide knowledge and technology to the people.

CITATIONS

1. Digest of Educational Statistics, 1975, National Center for Educational Statistics.
2. EFL - estimate based on national average of 100 sq ft per student in elementary/secondary schools, and 270 sq ft per full-time equivalent (FTE) student for higher education.
3. Estimate based on 1976 fall enrollment of:

   Higher Education 8,217,760 FTE ($170.30) = $1,399,484,500
   Elementary/Secondary 48,893,000 ($ 41.68) = $2,037,860,200
   (public and private)

   Higher education was assumed to have experienced same escalation rate as elementary/secondary.
4. According to the National Science Foundation, 25% of the nation's total energy consumption of 73 quadrillion Btu's is the heating and cooling bill (HCB).

   1 quadrillion Btu's = 1,000,000,000,000,000 or 10,000,000,000 (billion) therms.

   Higher Education: HEP Survey, higher education consumes .42 quads of energy, of which 21% is electricity. It is generally acknowledged that about 60% of the electrical consumption in non-electrically heated building is used for lighting. Therefore approximately 13.6% of the higher education energy load is used for lighting and 86.4% is used for HCB or .36 quads or 2%.

   Elementary/Secondary uses an estimated .75 quads of energy. PSECS estimates that 44% of this is electricity. Assuming 60% for lighting, then 73.6% of elementary/secondary energy use goes to HCB or .55 quads or 2.9%.

   Higher Education consumes approximately .36 quads or 2% of the nation's HCB.

   Elementary/Secondary consumes approximately .55 quads or 2.9% of the nation's HCB.

National Energy Consumption 73 quads

Education Energy Consumption 1.15 quads (11.5 billion therms) or 1.5%.

5. Federal Energy Administration, School Energy Survey.
6. EFL estimate based on extrapolation of FEA School Survey data and MDR data.

   Estimate assumes that the percentage of total utilities directly used for energy is 82%, this percentage is a conservative estimate.
7. FEA Energy Consumption in Commercial Industries.
8. NCES Higher Education Price Index.
9. FEA estimates energy reduction target for 1985 to be approximately one billion barrels of oil equivalents per year.

   A 30% reduction by education would be equal to 6.4 million barrels of oil equivalents per year or 6.4% of the nation's total energy conservation requirement for 1985.

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10. National Center for Education Statistics, Digest of Education Statistics, 1975 Edition.
11. National Center for Education Statistics, Projection of Education Statistics to 1984-85, 1976.
12. National Center for Education Statistics, Higher Education Price Index, 1976.

APPENDICES

A1 Education Energy Data Sheet

A2 FEA Median Energy Cost and Consumption Per Pupil, by Region and School District Size

A3 Energy Consumption in Public Schools by Fuel Type - 1974

A4 Elementary/Secondary Energy Consumption by Fuel Type Based on FEA Data

A5 Higher Education Energy Cost as a Percentage of Operating Budget, by Fuel Type, Region, and Type of Institution For Years 1972-73 and 1974-75

A6 Higher Education - Percentage Change in Energy Cost and Consumption, by Primary Fuel, Region and Type of Institution For Years 1972-73 and 1974-75

A7 Higher Education Price Index

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A10 Higher Education - Rank Ordering of Systems Convert Measures Implemented

A11 Capital Modifications for Elementary/Secondary Schools Developed by PSECS

A12 Listing of Retrofit and Systems Convert Measures at Selected Colleges and Universities

Appendix A1

EDUCATION ENERGY DATA SHEET FOR 1975-76

Institutions, Enrollment, Energy Cost Per Pupil, Square Footage, and Cost of Energy

1975-76	Number of schools	Number of pupils or FTEs (thousands)	Cost per pupil or FTE	Area in sq ft (millions)	Cost of energy (millions)
All		57,351		7,030	$3,199
Private Institutions		51,128		6,182	2,720
Private Institutions		6,224		848	479
Higher Education	3,026	8,479	$156.24	2,288	1,324
Public Institutions	1,442	6,522		1,760	1,019
Private Institutions	1,584	1,957		528	305
Public Institutions					
4-year	545	4,056		1,095	634
2-year	897	2,466		665	385
Private Institutions					
4-year	1,649	1,844		498	288
2-year	231	113		30	17
Elementary/Secondary		49,438	37.94	4,944	1,875
Public Schools	90,976*	44,838		4,484	1,701
Private Schools	17,700	4,600		460	174
Public Schools					
K-8	65,070	30,545		3,054	1,159
9-12	25,906	14,294		1,430	542
Private Schools					
K-8	14,000	3,400		340	157
9-12	3,700	1,200		120	56
Catholic Schools					
K-12	10,269	3,415		341	158

*1973-74

Source: National Center for Educational Statistics, Educational Facilities Laboratories

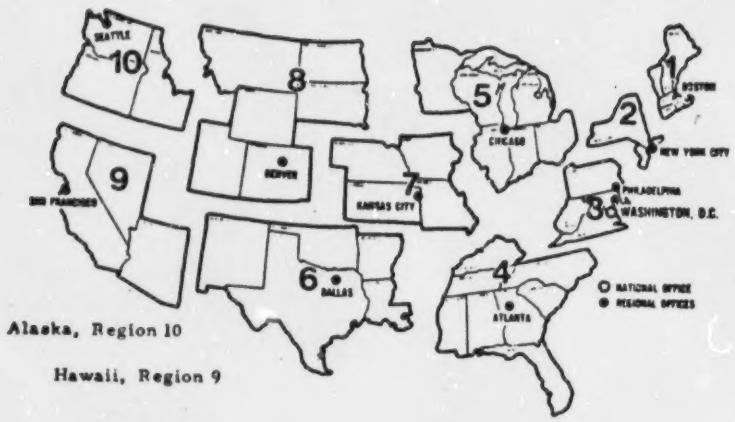
Appendix A2

MEDIAN ENERGY COST AND CONSUMPTION PER PUPIL FOR ELEMENTARY AND SECONDARY SCHOOLS BY REGION AND SCHOOL DISTRICT SIZE

		$/Pupil, All Fuel					Consumption/Pupil, All Fuel				
		1972-73		1974-75		% Change	1972-73		1974-75		% Change
Nation		$20.07	Rank	$29.77	Rank	48.3%	16,262*	Rank	15,768	Rank	-3.0%
Region	1	$24.46	2	$47.14	2	92.7%	17,728	6	16,914	7	-4.5%
	2	28.06	1	48.04	1	71.2	18,893	3	18,826	2	-0.3
	3	23.52	4	39.21	3	66.7	17,848	5	18,369	5	2.9
	4	15.80	3	24.99	7	58.1	10,117	10	9,972	9	-1.4
	5	24.09	3	36.30	4	50.6	19,005	2	19,750	1	3.9
	6	15.06	9	20.89	9	38.7	13,517	8	13,152	8	-2.7
	7	21.33	5	26.13	6	22.5	17,973	4	18,574	4	3.3
	8	18.77	7	24.93	8	32.8	17,691	7	18,816	3	6.3
	9	14.96	10	20.67	10	38.1	10,309	9	9,089	10	-11.8
	10	19.57	6	27.00	5	37.9	19,671	1	17,185	6	-12.6
Size	1	$17.51	6	$26.78	6	52.9%	8,524	6	7,706	6	-9.5
	2	20.58	3	28.84	4	40.1	15,482	5	16,377	4	5.7
	3	18.72	5	30.98	3	65.4	16,477	4	15,713	5	-4.6
	4	21.03	2	34.02	1	61.7	16,508	3	16,554	2	0.2
	5	19.98	4	28.09	5	40.5	17,839	1	17,185	1	-3.6
	6	22.83	1	32.88	2	44.0	16,894	2	16,393	3	-2.9

*000's BTU's per student

Regions



Alaska, Region 10

Hawaii, Region 9

Size Groups

1 over 25,000 students
2 10,000 - 24,999
3 5,000 - 9,999
4 2,500 - 4,999
5 1,000 - 2,499
6 under 1,000

Appendix A3

ENERGY CONSUMPTION IN PUBLIC SCHOOLS BY FUEL TYPE - 1974

Census Division	Fuel Type					
	Fuel Oil	Natural Gas	Coal	Electricity	Other*	Total
New England	75	1	4	17	3	100
Middle Atlantic	45	28	7	18	2	100
East North Central	14	53	14	17	2	100
West North Central	8	72	6	12	2	100
South Atlantic	38	32	6	24	Neg.#	100
East South Central	3	57	19	19	2	100
West South Central	1	78	0	21	Neg.#	100
Mountain	2	73	8	15	2	100
Pacific	11	59	Neg.#	27	3	100
United States	24	48	7	19	2	100

*Propane and Steam

#Negligible

Source: Federal Energy Administration

Appendix A4

ELEMENTARY/SECONDARY CONSUMPTION BY PERCENTAGE OF FUEL TYPE BASED ON MEDIAN PER PUPIL ENERGY CONSUMPTION

Fuel type	Per pupil consumption Btu's	Percentage
Fuel oil	4,699,530	30
Natural gas	5,987,400	38
Coal	2,044,000	13
Electricity	1,905,508	12
Propane	1,132,342	7
	15,768,782	101 (rounded)

Source: Educational Facilities Laboratories, Federal Energy Administration

Appendix A5

ENERGY COST AS A PERCENTAGE OF OPERATING BUDGET FOR 1972-73 AND 1974-75

Percentage of budget allocated for energy	Percentage of institutions		Primary Fuel						Region											
			Oil		Gas		Coal		East		Mid-west		South		West		Graduate Schools		4-Year Colleges		2-Year Colleges	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
0-3%	62	32	82	35	68	46	73	18	47	6	65	43	61	25	86	83	86	60	65	28	55	37
3-4%	86	59	88	55	88	73	92	62	82	41	83	75	90	44	95	94	96	81	86	57	85	61
4-5%	94	78	89	75	95	87	100	81	95	67	96	85	94	72	95	94	97	90	95	80	94	78
5+ %	6	22	11	25	5	13	0	19	5	33	4	15	6	28	5	6	3	10	5	20	6	22
Cost per Therm	.131	.235	.153	.330	.116	.188	.102	.190	.165	.132	.124	.196	.116	.229	.117	.175	.118	.215	.113	.239	.169	.304

Source: American Council of Education, HEP Survey #31

A = 1972-1973

B = 1974-1975

Appendix A6

HIGHER EDUCATION: PERCENTAGE CHANGE IN ENERGY CONSUMPTION AND COST BY PRIMARY FUEL, REGION, AND TYPE OF INSTITUTION BETWEEN 1972-73 AND 1974-75

		Primary Fuel			Region						
Category	All institutions	Oil	Gas	Coal	East	Mid-west	South	West	Graduate Schools	2-Year Colleges	4-Year Colleges
Therms	-5.6	-15.8	-9.8	-3.3	-3.1	-5.9	-6.7	-6.3	-5.2	-3.2	-15.2
Cost	70.1	81.6	45.8	79.2	94.3	48.3	83.8	40.1	73	73.9	52.3
Cost per Therm	79	115	62	86	101	58	97	50	82	80	80

Source: Amercian Council of Education, HEP Survey #31

Appendix A7

HIGHER EDUCATION PRICE INDEX

Index: 1967=100	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76
Personnel compensation						
Professional salaries	127.5	132.5	138.4	145.4	153.6	161.6
Faculty	127.2	131.7	137.4	144.4	152.3	161.1
Extension and public service personnel	127.2	131.7	137.4	144.4	152.3	161.1
Administrative and institutional service personnel	(129.2)	135.8	(143.3)	150.8	(160.7)	163.6
Library personnel	(128.5)	135.1	(142.2)	149.4	(157.1)	165.0
Nonprofessional salaries and wages	126.9	136.1	144.3	153.4	165.7	179.1
Craftsmen	127.9	137.9	146.6	157.9	(172.1)	(186.2)
Clerical	125.7	133.4	140.6	149.6	164.0	176.0
Operators and laborers	128.1	138.5	147.2	157.7	(171.9)	186.0
Fringe benefits	162.0	180.2	197.7	222.0	241.0	266.7
Contracted services and materials						
Services	119.3	126.4	131.9	138.1	150.2	157.4
Data processing	107.0	111.5	116.4	119.0	124.2	131.5
Communication	108.1	117.4	120.8	126.1	132.2	140.5
Transportation	135.6	143.2	146.3	148.2	153.3	170.8
Printing and duplicating	119.7	126.5	132.1	140.1	159.9	163.7
Supplies and materials	110.3	112.6	116.3	131.6	164.2	171.8
Equipment	115.1	119.4	123.1	130.6	154.1	163.2
Books and periodicals	144.6	163.8	177.0	195.3	219.5	251.8
Hardcover books	146.9	166.9	173.3	179.8	207.6	238.6
U.S. periodicals	139.9	156.7	177.8	217.7	238.0	268.2
Utilities	114.6	122.4	129.0	158.3	202.9	219.1

(Figures in parentheses are estimates.)

SOURCE: D. KENT HALSTEAD

Index numbers above equal per cent of 1967 costs for various goods and services.

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Appendix A8

HIGHER EDUCATION: RANK ORDERING OF QUICK FIX MEASURES IMPLEMENTED

Rank	Measure	(2 = 533) Percentage
1	Fix minor water leaks	93.2
2	Inspection and correction of valve functions and air filtration systems	89.1
3	Reduction in illumination levels and lamp wattage	86.8
4	Specific temperature range - 65-68 degrees in winter	84.8
5	Specific temperature range - 75-80 degrees summer	84.1
6	Inspection and regularized maintenance of steam traps	78.4
7	Manual monitoring of buildings	75.2
8	Substantial night and weekend building shutdown	72.8
9	Manual reduction of fresh air makeup	69.3
10	Reduction of domestic hot water temperature	66.2
11	Campus-wide energy awareness program	65.5
12	Restrictive policy on air conditioning installation	46.6
13	Reset automatic flush valves	40.8
14	ORSAT analysis of flue gasses	39.7
15	Reduction of building heat, leakage by using blinds and drapes	38.1
16	Faculty, staff and student energy committee	34.2
17	Consolidation of activities into fewer buildings, particularly during evenings and weekends	34.2
18	Energy sessions with building occupants	30.6
19	Scheduling of institutional vacations during energy intensive periods	27.1
20	Work schedule adjustments to maximize daylight working hours	25.3
21	Restrictive policy on appliance usage	25.2
22	Development of energy efficient space allocation practices	20.9
23	Appointment of building energy monitors	20.4

Note: This list does not pretend to be all inclusive, but lists major and common Quick Fix measures.

Source: American Council of Education, HEP Survey #31

Appendix A9

HIGHER EDUCATION: RANK ORDERING OF RETROFIT MEASURES IMPLEMENTED

Rank	Measure	(n = 530) Percentage
1	Conversion from incandescent to fluorescent, mercury vapor, quartz, sodium and other more efficient light fixtures	78.8
2	Utilization of time clocks on lighting systems	72.5
3	Analysis of electrical rate structures, power factors, load profiles and demand peaks	67.0
4	Weather stripping, storm windows, caulking, sun screens, blinds	60.3
5	Installation of variable speed drives	57.6
6	Review of existing mechanical systems and controls to identify capital investment options	57.1
7	Automated reduction of fresh air makeup	53.8
8	Improve steam line insulation	53.7
9	Installation of water savings shower heads or flow restraints	52.6
10	Installation of motorized steam valves	52.0
11	Revision of light switch circuitry to reduce overlighting	50.2
12	Roof and wall insulation	47.2
13	Installation of solenoid valves on water cooled equipment	37.0
14	Categorization of campus for energy cost and consumption analysis by functional classification of facilities	34.4
15	Use of task vs. area lighting	33.4
16	Rezoning of heating/cooling systems	32.7
17	Centralized monitoring of buildings	29.1
18	Installation of variable speed drives	22.2
19	Infrared photographic survey to identify heat loss	4.7

Source: American Council of Education, HEP Survey #31

Appendix A10

HIGHER EDUCATION: RANK ORDERING OF SYSTEMS CONVERT MEASURES IMPLEMENTED

Rank	Measures	(n = 527) Percentage
1	Automation of power plants	43.8
2	Independent zoned environment controls for laboratories and other specialized space	38.3
3	Conversion to alternate fuel	35.2
4	Rewiring major electrical systems to minimize demand charges and to avoid established new peaks	29.2
5	Installation of central computerized controls	22.5
6	Installation of computerized building monitoring systems	20.6
7	Replacement or alteration of reheat systems	17.2
8	Installation of waste heat recovery systems in boiler and chiller water plants	13.6
9	Solar energy systems	.8

Source: American Council of Education, HEP Survey #31

Appendix A 11

CAPITAL MODIFICATIONS DEVELOPED BY EFL's PUBLIC SCHOOL ENERGY CONSERVATION SURVEY (PSECS)

Seal Windows and Doors Improve tightness of windows and doors to reduce infiltration by 50 percent. Estimated cost: $0.15 per sq ft of floor area.

Wall Insulation, Increase By R=N Increase wall insulation to bring wall to U-factor of 0.06. Although not always possible, the cost estimate is based on adding rigid insulation to interior face of wall. Estimated cost: $1.00 per sq ft of wall plus $0.08 per sq ft of wall for each R unit (=1/U).

Reduce Glass By NN, Pct Reduce area of single sheet glass by NN percent by replacing glass with panels having U-factor of 0.10. Estimated cost: pre-1944 plants: $8.00 per sq ft replaced, new frames; post-1945 plants: $3.50 per sq ft replaced, assuming reuse of frames.

Double Glaze Windows Replace single sheet glass with double glass or equivalent insulating glass. Estimated cost: pre-1944 plants: $11.50 per sq ft of glass, new frames; post-1945 plants: $7.00 per sq ft, assuming reuse of frames.

Roof Insulation, Increase By R=N Increase roof insulation to bring roof to U-factor of 0.06. Four possible approaches based on roof type as reported on form PS-9. Estimated cost: TYPE 1 - blow-wool into attic, $0.01 per sq ft per unit of R; TYPE 2 - blow-wool above ceiling, $0.65 per sq ft (holes and patch) plus $0.01 per sq ft per unit of R; TYPE 3 - batts above existing ceiling, $0.038 per sq ft of roof per unit of R; TYPE 4 - rigid board above old roof, reroof, $0.60 per sq ft of roof plus $0.08 per sq ft per unit of R.

Add Night Setback For systems without night setback, add unoccupied setback control including time-clocks. Setback to 60 F (radiation); 50 F (air systems) or off in mild climates assumed. Estimated cost: $1,000 for first system (air or water) plus $250 for each additional system.

Shut OA Dampers at Night For plants with setback by cycling fans with outside air dampers open, shut these dampers at night. Estimated cost: too specific to individual systems, range of $1,000 to $2,000 per system.

Shut Heat Off At Night In mild climates, totally shut down air system at night. Estimated cost: no cost assumed.

Add Warm-Up Cycle Add a warm-up cycle to systems having return air which do not have such a cycle. Estimated cost: $450 per system (manually controlled at $150 per system - not recommended).

Supply Air to 65 F For HVAC systems, raise winter mixed air temperature to 65 F. Estimated cost: no cost assumed.

Reduce OA to NN Percent For gyms and auditoriums only, reduce outside air percentage to figure given. Estimated cost: varies by system, in some cases none.

Vary MAT With Demand For single-zone systems in gyms and auditoriums only, modify system controls to provide mixed air temperature based on demand instead of fixed temperature. Estimated cost: $200 per system.

Disconnect Reheat Coils Disconnect reheat coils and adjust deck and supply air temperatures accordingly. This modification should definitely be assessed by professionals prior to implementation. Estimated cost: cost of adjustments only.

Eliminate Multizone Overlap Typically between 60 F and 70 F outdoor temperature multizone units simultaneously call for heating and cooling. This modification suggests that this overlap be eliminated by setting both heating and cooling deck lockout at 65 F. Estimated cost: $350 per system.

Marginal Hr/Day-Reg Ses This is not a modification rather it is an estimate of the saving in energy and dollars of running the plant one hour less (or more if used as a cost estimate) each day of the regular session that the special use space or general area is used. For each space analyzed, the computer assumes that all of the area attributed to that space on form PS-4 or PS-20 is in use. If a partial use is desired, multiply the given figures by

the percentage use. The actual hour given is the last hour of operation each day as reported to PSECS.

Replace Absorption Chlrs Replace existing absorption chillers with electric centrifugal units. Estimated cost: $400 per ton capacity.

Install Modular Boilers Replace existing boilers with modular type units. Estimated cost: $14 per MBH capacity.

Sequenced Pumps-Heating Replace existing hot water circulating pumps with multiple stage sequenced pumps. If chilled water is circulated as well, savings for this use are included. Estimated cost: $3,500 per plant.

Cover Swimming Pool Cover outdoor swimming pools during periods of non-use. This modification assumes a permanent installation providing this cover. Estimated cost: $2.50 per sq ft of pool surface.

This list is by no means an exhaustive listing of all possibilities. In many plants, unique opportunities exist for reduced energy use. The purpose of this list is to provide direction to a district in determining if they can benefit from engaging professional talent to fully develop these and other energy conservation alternatives at their schools.

Appendix A12

RETROFIT AND SYSTEMS CONVERT MEASURES AT SELECTED COLLEGES AND UNIVERSITIES

This listing is illustrative of some of the facility modifications in the planning stage or in operation. The listing is representative of institutions undertaking these measures. In a few cases "Quick Fix" measures have also been included as it was not possible to remove these energy savings from the over all institutional savings.

Delaware County Community College plans to install remote switching light controls. Cost $4,000, savings $20,000 annually.

Dartmouth College plans to replace present campus lighting with metal halide lighting. Cost avoidance will be $10,000 annually.

Southern Illinois University installed a demand (electrical) control system. Cost $60,000, savings $30,000 annually.

Brigham Young University will install heat pumps in their library. Savings anticipated are 26% in energy and 21% in energy cost.

Mount Holyoke modified ventilating system. Cost $5,233, savings $7,134 annually. They are also installing a central digital control system (phase 1 or 3 phases). Cost $31,000, savings $7,500 annually.

University of Minnesota has installed an automated control network for 65 of their buildings. Savings $500,000 annually.

MIT modified 200 air mixing boxes to variable volume. Cost $51,500, savings $41,000 annually. They also installed a computer monitoring and control system for 35 buildings. Cost $1,700,000, savings $785,000 annually.

Texas A & M is installing a computer monitoring and control system. Cost $1,500,000, savings $500,000 annually. This is a good example of the potential of computer controls. Their annual fuel budget is $10 million. If the computer system saves only 5% - and they are sure it will save more - it will pay for itself in three years.

University of California at Berkeley is completing specifications for a campus computer control system. Estimated cost $1,500,000. Payback period two to three years.

San Jose State University will install solar hot water heaters for one of their dormitories. Cost $125,000, savings $11,500. Payback period 11 years.

Temple University is planning to upgrade the building controls to permit equipment shutdown automatically. This will be incorporated with night setbacks and interconnection of steam absorption water chillers during light operational periods. Cost $57,000, savings $38,000.

S.U.N.Y. College at Oswego is studying the feasibility of retrofiting of economizers to two 50,000 lb/hr steam boilers. Cost $146,000, savings $43,000.

Johns Hopkins University is installing a central control system to shave elec ical peaks and program on/off of equipment. Cost $72,000, ngs $72,000 annually.

Ohio State University initiated a program of conversion of high pressure dual duct and terminal reheat systems to variable volume, as well as reduction in fin, pump and chiller power, installation of time clocks and reduction in temperature, light levels and air mix. Cost $206,344, savings $428,404.